

- Series Circuit Principles and Equations:
 - A series circuit is one with all the loads in a row, like links in a chain. There is only one path for the electrons to flow. If one of the resistors is removed, the current stops.
 - **Resistance in a Series Circuits:**
 - The total resistance in a series circuit is equal to the sum of all of the resistors.

$$R_T = R_1 + R_2 + R_3 + \dots + R_N$$

Where:

R_T = Total resistance

R_1 = Resistance of R_1

R_2 = Resistance of R_2

R_3 = Resistance of R_3

R_N = Resistance of R_N

N = The number of resistors in the series circuit.

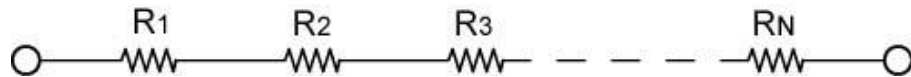


Figure 1

- More than one resistor in series can substitute for a resistor value that is unavailable.
- In a series circuit, the large resistor dominates if it is series with a small resistor.
- **Voltage in a Series Circuit:**
 - Kirchhoff's Voltage Law: The total voltage applied to a series circuit is equal to the total of the individual voltage drops across each resistor in the series circuit. (In more general terms, the algebraic sum of all voltages, both source and drops, around a closed loop is equal to zero.)
 - Mathematically:

$$V_T = V_1 + V_2 + V_3 + \dots + V_N, \text{ or}$$

$$V_T - V_1 - V_2 - V_3 - \dots - V_N = 0$$

Where:

V_T = Total voltage applied to the series circuit

V_1 = Voltage drop across R_1

V_2 = Voltage drop across R_2

V_3 = Voltage drop across R_3

V_N = Voltage drop across R_N

N = The number of resistors in the series

- Example of Voltage in a Series Circuit (Figure 2):
 - The voltage at Point D is 0 volts when both multimeter leads are connected to the same point.
 - Leaving the common lead at Point D, the voltage jumps to +10 V at Point A because the battery supplies the energy to increase the potential by +10 V.
 - There is a 2 V drop across R_1 (-2 V) causing the voltage at Point B to drop to +8 V.
 - Likewise, R_2 causes a further 3 V drop (-3 V) in the voltage bringing the voltage at Point C to +5 V.
 - Finally, R_3 drops the voltage 5 more volts (-5 V) to return the voltage back to 0 V at Point D.

$$V_T - V_1 - V_2 - V_3 = 0$$

$$10\text{ V} - 2\text{ V} - 3\text{ V} - 5\text{ V} = 0$$

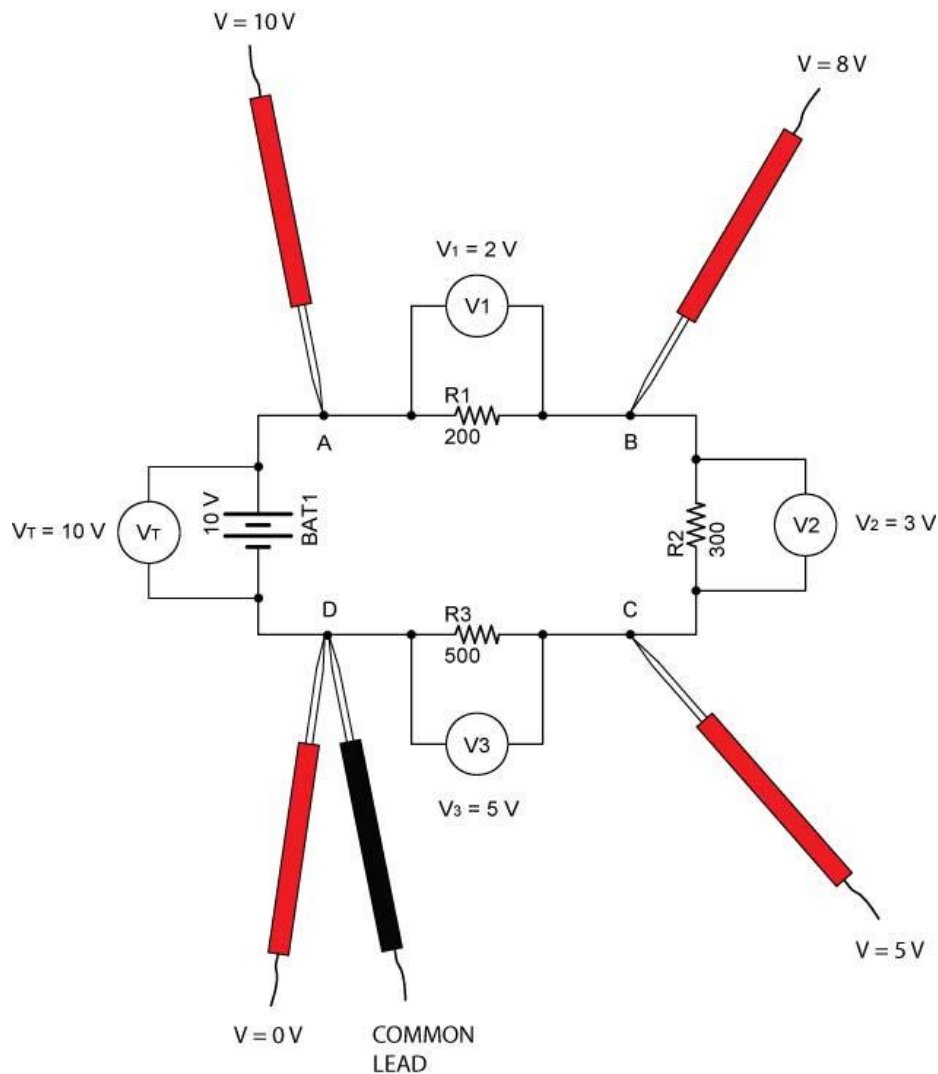


Figure 2

○ **Current in a Series Circuit:**

- A series circuit provides only one path for the current so it must have the same value at any point in the circuit.
- Mathematically:

$$I_T = I_1 = I_2 = I_3 = \dots I_N$$

Where:

I_T = Total current

I_1 = Current through R_1

I_2 = Current through R_2

I_3 = Current through R_3

I_N = Current through R_N

N = The number of resistors in the series

- Example of Current in a Series Circuit (Figure 3):

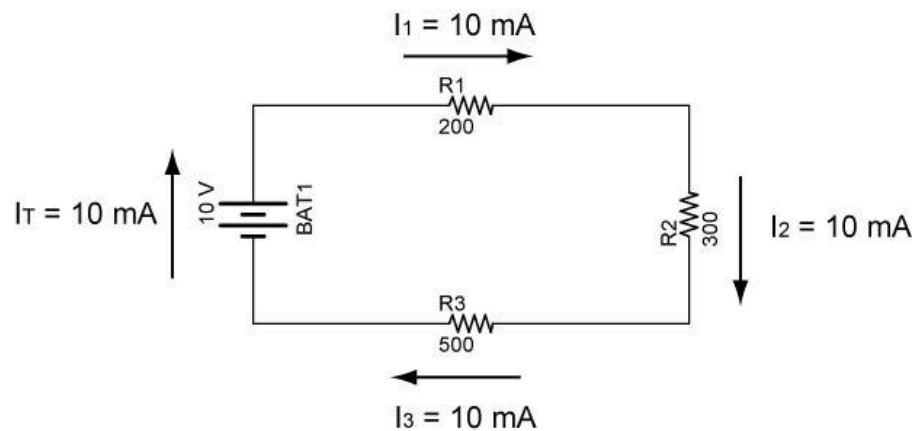


Figure 3

○ **Power in a Series Circuit:**

- The total amount of power consumed in a series circuit is equal to the source voltage multiplied by the circuit current. The total power consumed is also equal to the sum of the power consumed by each resistor.
- Mathematically:

$$P_T = P_1 + P_2 + P_3 + \dots + P_N$$

Where:

P_T = Total power consumed

P_1 = Power consumed by R_1

P_2 = Power consumed by R_2

P_3 = Power consumed by R_3

P_N = Power consumed by R_N

N = The number of resistors in the series circuit.

- Power also equals the product of the total voltage and the total current.

$$P_T = V_T \times I_T$$

Where:

P_T = Total power consumed

V_T = Total voltage applied to the series circuit

I_T = Total current

- Example of Power in a Series Circuit (Figure 4):

$$P_T = P_1 + P_2 + P_3$$

$$P_T = V_1 \times I_1 + V_2 \times I_2 + V_3 \times I_3$$

$$P_T = 2 \text{ V} \times 0.01 \text{ A} + 3 \text{ V} \times 0.01 \text{ A} + 5 \text{ V} \times 0.01 \text{ A}$$

$$P_T = 0.02 \text{ W} + 0.03 \text{ W} + 0.05 \text{ W}$$

$$P_T = 0.10 \text{ W}$$

Also,

$$P_T = V_T \times I_T$$

$$P_T = 10 \text{ V} \times 0.01 \text{ A}$$

$$P_T = 0.10 \text{ W}$$

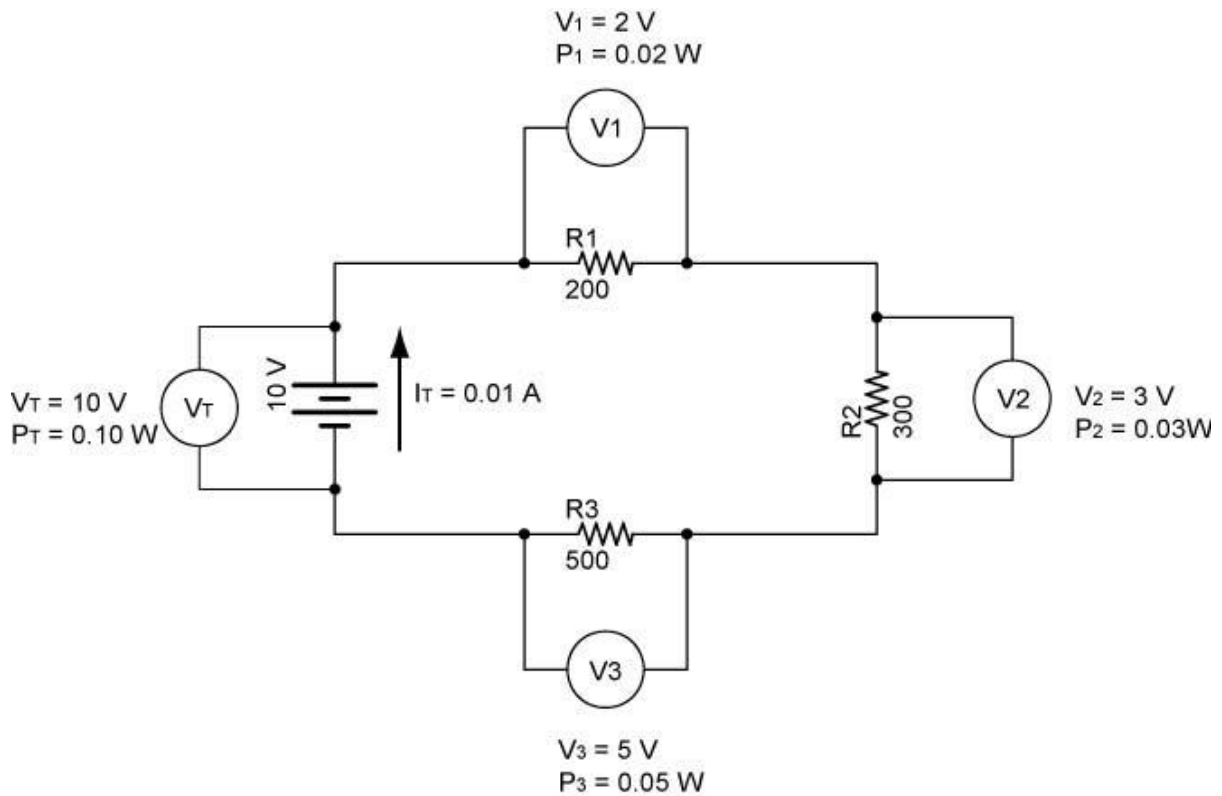


Figure 4

- Solving for Resistance, Voltage, and Current in a Series Resistor Circuits:

- Four equations are used to solve series resistor circuits. They are:

$$R_T = R_1 + R_2 + R_3 + \dots + R_N$$

$$V_T = V_1 + V_2 + V_3 + \dots + V_N$$

$$I_T = I_1 = I_2 = I_3 = \dots = I_N$$

$$V = I \times R$$

$V = I \times R$ can be applied to the total circuit ($V_T = I_T \times R_T$) and to individual resistors ($V_1 = I_1 \times R_1$).

- A table will be used to help solve our circuits. To begin, a table as shown in Table 1 corresponds to the circuit in Figure 5:

	Resistance	Voltage	Current
R1	R1 = 200 Ω		
R2	R2 = 300 Ω		
R3	R3 = 500 Ω		
Total		$V_T = 10 \text{ V}$	

Table 1

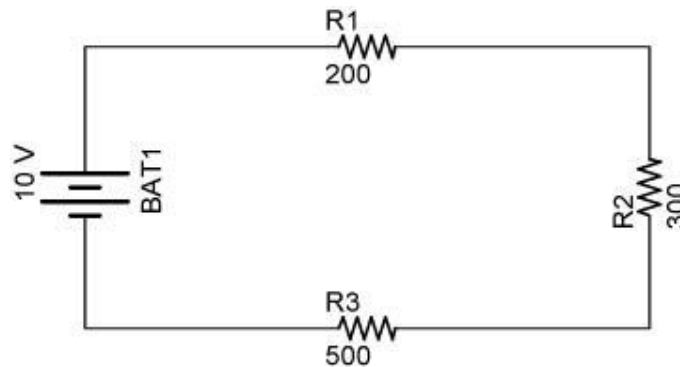


Figure 5

- Table 2 lists all of the unknowns that will be solved.

	Resistance	Voltage	Current
R1	R1 = 200 Ω	V1	I1
R2	R2 = 300 Ω	V2	I2
R3	R3 = 500 Ω	V3	I3
Total	R _T	V _T = 10 V	I _T

Table 2

- Step 1: Find R_T:

$$R_T = R_1 + R_2 + R_3$$

$$R_T = 200 \Omega + 300 \Omega + 500 \Omega$$

$$R_T = 1000 \Omega$$

See Table 3:

	Resistance	Voltage	Current
R1	R1 = 200 Ω	V1	I1
R2	R2 = 300 Ω	V2	I2
R3	R3 = 500 Ω	V3	I3
Total	R _T = 1000 Ω	V _T = 10 V	I _T

Table 3

- Step 2: Solve for I_T:

$$I_T = V_T / R_T$$

$$I_T = 10 \text{ V} / 1000 \Omega$$

$$I_T = 0.010 \text{ A or } 10 \text{ mA}$$

See Table 4:

	Resistance	Voltage	Current
R1	R1 = 200 Ω	V1	I1
R2	R2 = 300 Ω	V2	I2
R3	R3 = 500 Ω	V3	I3
Total	R _T = 1000 Ω	V _T = 10 V	I _T = 0.01 A

Table 4

- Step 3: Find I₁, I₂, and I₃.

$$I_T = I_1 = I_2 = I_3 = 0.010 \text{ A}$$

See Table 5:

	Resistance	Voltage	Current
R1	R1 = 200 Ω	V1	I1 = 0.01 A
R2	R2 = 300 Ω	V2	I2 = 0.01 A
R3	R3 = 500 Ω	V3	I3 = 0.01 A
Total	R _T = 1000 Ω	V _T = 10 V	I _T = 0.01 A

Table 5

- Step 4: Solve for V₁, V₂, and V₃.

$$V_1 = I_1 \times R_1$$

$$V_1 = 0.010 \text{ A} \times 200 \Omega$$

$$V_1 = 2 \text{ V}$$

$$V_2 = I_2 \times R_2$$

$$V_2 = 0.010 \text{ A} \times 300 \Omega$$

$$V_2 = 3 \text{ V}$$

$$V_3 = I_3 \times R_3$$

$$V_3 = 0.010 \text{ A} \times 500 \Omega$$

$$V_3 = 5 \text{ V}$$

See Table 6:

	Resistance	Voltage	Current
R1	R1 = 200 Ω	V1 = 2 V	I1 = 0.01 A
R2	R2 = 300 Ω	V2 = 3 V	I2 = 0.01 A
R3	R3 = 500 Ω	V3 = 5 V	I3 = 0.01 A
Total	R _T = 1000 Ω	V _T = 10 V	I _T = 0.01 A

Table 6

- Not every series circuit to be solved will have the source voltage and all of the resistor values. To solve the unknowns for each circuit, use the four equations in bold above in whatever the order is necessary for the solution.
- Since all of the resistances, voltages, and currents are solved in the present problem, the power can now be calculated.

- Solving for Power in a Series Resistor Circuits:
 - Two equations are used to solve for power in a series resistor circuit. They are:

$$P_T = P_1 + P_2 + P_3 + \dots + P_N$$

$$P = V \times I$$

$P = V \times I$ can be applied to the total circuit ($P_T = V_T \times I_T$) and to individual resistors ($P_1 = V_1 \times I_1$).

- A column for power will be added to the table already used to solve our circuit.

	Resistance	Voltage	Current	Power
R1	R1 = 200 Ω	V1 = 2 V	I1 = 0.01 A	P1
R2	R2 = 300 Ω	V2 = 3 V	I2 = 0.01 A	P2
R3	R3 = 500 Ω	V3 = 5 V	I3 = 0.01 A	P3
Total	R _T = 1000 Ω	V _T = 10 V	I _T = 0.01 A	P _T

Table 7

- Step 5: Solve for P_1 , P_2 , P_3 , and P_T .

$$P_1 = V_1 \times I_1$$

$$P_1 = 2 \text{ V} \times 0.010 \text{ A}$$

$$P_1 = 0.020 \text{ W}$$

$$P_2 = V_2 \times I_2$$

$$P_2 = 3 \text{ V} \times 0.010 \text{ A}$$

$$P_2 = 0.030 \text{ W}$$

$$P_3 = V_3 \times I_3$$

$$P_3 = 5 \text{ V} \times 0.010 \text{ A}$$

$$P_3 = 0.050 \text{ W}$$

$$P_T = P_1 + P_2 + P_3$$

$$P_T = 0.020 \text{ W} + 0.030 \text{ W} + 0.050 \text{ W}$$

$$P_T = 0.100 \text{ W}$$

See Table 8:

	Resistance	Voltage	Current	Power
R1	R1 = 200 Ω	V1 = 2 V	I1 = 0.01 A	P1 = 0.02 W
R2	R2 = 300 Ω	V2 = 3 V	I2 = 0.01 A	P2 = 0.03 W
R3	R3 = 500 Ω	V3 = 5 V	I3 = 0.01 A	P3 = 0.05 W
Total	R _T = 1000 Ω	V _T = 10 V	I _T = 0.01 A	P _T = 0.10 W

Table 8